AQA Chemistry
GCSE Teacher calculation sheet C4.8

Titration calculations

Specification references

- C3.4 Using concentrations of solutions in mol/dm^3 (H)
- MS 1a, 1c, 3b, 3c
- WS 4.2, 4.3, 4.6

Aims

This worksheet will give students practice in converting between numbers of moles, volume, and concentration. It will also give them practice in completing titration calculations.

Learning outcomes

After completing this worksheet, students should be able to:

- calculate the unknown concentration of a reactant in a neutralisation reaction when the volumes are known and the concentration of one reactant is also known.

Teacher notes

In this worksheet, students are led through the steps required to determine the concentration of an unknown acid or alkali from titration data. Before attempting these calculations, they must be confident with the use of the equation:

$$\text{concentration (mol/dm}^3\text{)} = \frac{\text{amount of substance (mol)}}{\text{volume (dm}^3\text{)}}$$

Significant figures have not been discussed in the worksheet, but it may be worth introducing the topic to your students when looking at the answers. For some questions, students will need to be able to express their final answer to a specified number of significant figures. For others the final answer should only be expressed to the same number of significant figures as the numbers used to calculate it.

The calculations covered in this maths worksheet are some of the most difficult that students will be asked to perform. Although the students may be confident in performing the individual steps needed, they often struggle with working out the required steps if presented with an unscaffolded question. This worksheet guides them through the steps with a worked example and a scaffolded question, before presenting them with an exam-style question where they are expected to complete the calculation unaided.

It is common for students to struggle with interpreting the information in the question. To help them with this, they are encouraged throughout to sketch a labelled diagram of the titration equipment to indicate which solution is where. In addition, they may find the RSC's Problem Solving Tutor helpful (http://www.rsc.org/learn-chemistry/resources/problem-solving-tutor/).

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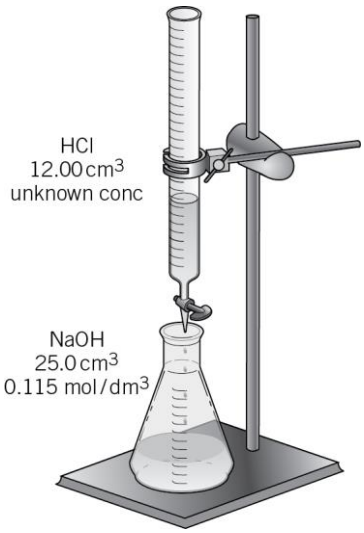
Maths skills links

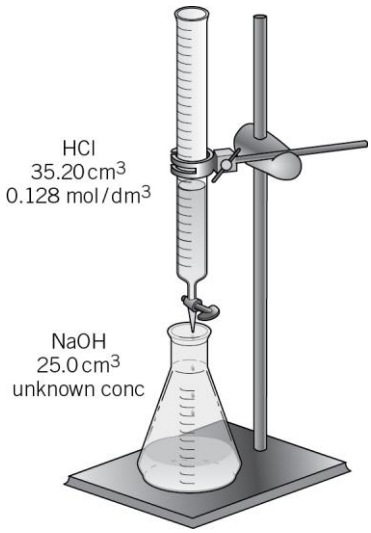
The types of calculations involved in this worksheet and the maths skills required are similar to those needed throughout quantitative chemistry. More specifically, students will need to be able to convert between volumes in different units and to rearrange equations.

Answers

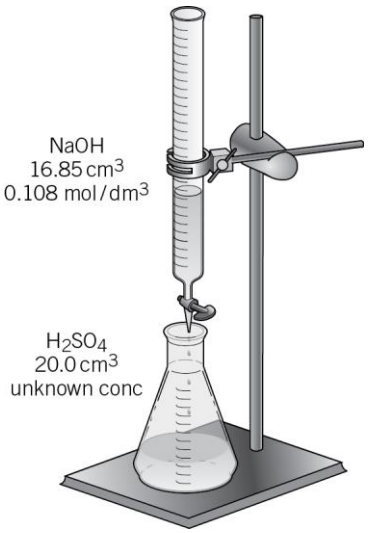
1 a



b



c



(for a, b and c: 1 mark for the correct chemical with its concentration and volume in the burette; 1 mark for the correct chemical with its concentration and volume in the conical flask)

2 a i amount (mol) = 0.108 mol/dm^3 × 0.0350 dm^3 = 0.00378 mol (*1 mark*)

ii 41.8 cm^3 = 0.0418 dm^3 (*1 mark*)

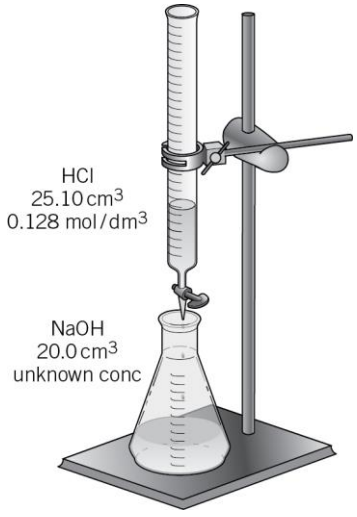
amount (mol) = 0.0501 mol/dm^3 × 0.0418 dm^3 = 0.00209 mol (*1 mark*)

b i concentration (mol/dm^3) = 0.345 mol ÷ 0.0250 dm^3 = 13.8 mol/dm^3 (*1 mark*)

ii 18.90 cm^3 = 0.01890 dm^3 (*1 mark*)

concentration (mol/dm^3) = 0.480 mol ÷ 0.01890 dm^3 = 25.4 mol/dm^3 (*1 mark*)

3 a (*2 marks*)



b 25.10 $cm^3 = 0.02510\ dm^3$ (*1 mark*)

Amount of HCl = 0.02510 $dm^3 \times 0.128\ mol/dm^3 = 0.00321$ mol (*1 mark*)

c $HCl + NaOH \rightarrow NaCl + H_2O$ (*1 mark*)

d Amount of NaOH in 20.0 $cm^3 = 0.00321$ mol (*1 mark*)

e 20.0 $cm^3 = 0.020\ dm^3$ (*1 mark*)

Concentration = 0.00321 mol ÷ 0.020 $dm^3 = 0.161\ mol/dm^3$ (*1 mark*)

4 Amount of NaOH in 25.00 cm^3 of a solution of 0.0998 mol/dm^3

= 0.0998 $mol/dm^3 \times 0.025\ dm^3$

= 0.002495 mol (*1 mark*)

Amount of HNO_3 in 21.80 $cm^3 = 0.002495$ mol (*1 mark*)

Concentration of HNO_3 = 0.002495 mol ÷ 0.02180 dm^3

= 0.1144 mol/dm^3 (*1 mark*)

= 0.114 mol/dm^3 (to three significant figures) (*1 mark*)

5 **a** $2KOH + H_2SO_4 \rightarrow K_2SO_4 + 2H_2O$ (*1 mark*)

b 0.206 mol/dm^3

Correct answer to three significant figures. (*5 marks*)

If answer incorrect award a maximum of 4 marks for the following steps:

- moles of $H_2SO_4 = 0.00258$ mol
- moles of KOH = 0.00516 mol
- Concentration of KOH = moles of KOH ÷ 0.0250 dm^3
- Answer to three significant figures.